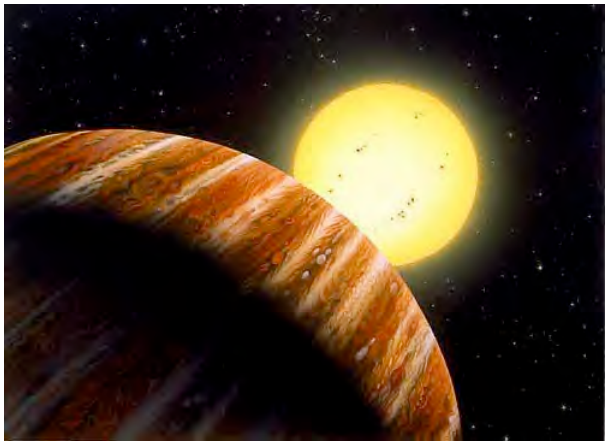
Where Are the Distant Worlds? Star Maps

About the Activity

Where are the distant worlds in the night sky? Use a star map to find constellations and to identify stars with extrasolar planets. (Northern Hemisphere only, naked eye)



Topics Covered

- How to find Constellations
- Where we have found planets around other stars

Participants

Adults, teens, families with children 8 years and up
If a school/youth group, 10 years and older
1 to 4 participants per map

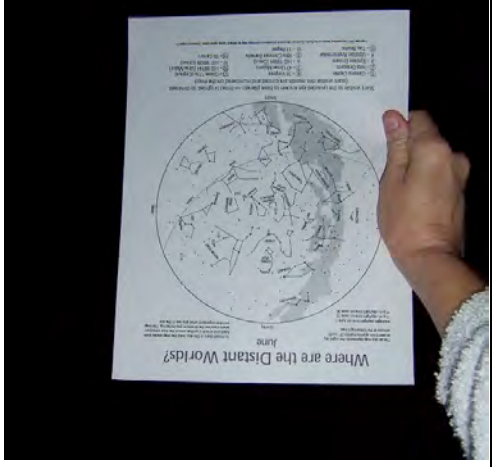
Materials Needed

- Current month's Star Map for the public (included)
- At least one set Planetary Postcards with Key (included)
- A small (red) flashlight
- *(Optional)* Print list of *Visible Stars with Planets* (included)

Location and Timing

Use this activity at a star party on a dark, clear night. Timing depends only on how long you want to observe.

Detailed Activity Description

Leader's Role	Participants' Roles (Anticipated)
Introduction: *To Ask:* Who has heard that scientists have found planets around stars other than our own Sun? How many of these stars might you think have been found? Anyone ever see a star that has planets around it? (our own Sun, some may know of other stars) We can't see the planets around other stars, but we can see the star. We can also show you a picture of what the system might look like. *To Say:* We're going to look at a map that will show us where to find these stars in the sky. NASA missions are being designed right now to find more stars with planets and to find out which planets might have life! We'll use the star map to find the constellations the stars are in and then find the stars with planets.	Participants begin to think about and respond to questions about extrasolar planets beyond our Solar System.
To Ask: What's a constellation? (make sure the participants understand)	Participants share, learn, or are reminded of what constitutes a constellation.
To Do: Demonstrate how to use the star map to find a constellation and one of the stars. Assist participants in finding other constellations and stars with planets. **To demonstrate how to use a star map:** If facing North, hold the map up against the sky and orient the star map so that North on the map is down - toward the northern horizon (see photo to the right). If facing East, orient the map so that East on the star map is down toward the eastern horizon. Facing North, using the star map.  	Participants practice using a star map to find constellations and stars with planets.

Leader's Role	**Participants' Roles (Anticipated)**
To Do: Show participants the Planetary PostCard for the star they found in the sky. You will need a small flashlight.	
To Ask: Using the Planetary PostCard you can ask questions to stimulate discussion: • That star is hotter/colder than our Sun. How do you think that might affect its planets? • Here is where one of the planets orbits that star. What would it be like to live on this planet (or one of its moons)? • If Earth was orbiting that star, what might be different? • How big do you suppose this planet is compared to the planets in our Solar System? • Do you think we have found all the planets in this system?	Think about and discuss another planetary system
Additional Discussion on Epsilon Eridani – the nearest star we know of with planets (besides the Sun!) *To Say:* The fastest speed recorded for a spacecraft was 150,000 miles per hour, reached by the Helios satellite that is in orbit around the Sun. That's 42 miles per *second*. *To Ask:* How long do you would it take to for someone living on Epsilon Eridani's planet about 10 light years away, to get into our Solar System if they were traveling at the speed of our fastest spacecraft (light travels at 186,000 miles per second and our fastest spacecraft travels at about 42 miles per second)? Or for us to reach them? The spacecraft would travel at 2/10,000th the speed of light (42 divided by 186,000 = 0.00022). So 1 light year would take 5,000 years. Epsilon Eridani is about 10 light years from us. So . . . 10 years X 5,000 = 50,000 YEARS to get there. *To Discuss:* • What would we have to do to take such a trip? • How would we stay in communication with the spacecraft? • Would a manned or unmanned spacecraft be a better idea? Why? • How long would it take for us to know the spacecraft had arrived? • How different do you think Earth will be in 50,000 years?	

Helpful Hints

- TO PROMOTE YOUR CLUB: You may want to copy your club's information and schedule on the back side of the star map which you hand out.

- Emphasize that the stars marked on the star maps have planetary systems of their own, just like our star, the Sun, does.

- When you discuss other stars that have planets, some people may think you mean that some of OUR planets (like Jupiter or Saturn) are near other stars. A common misconception is that the stars are sprinkled among the planets of our Solar System. A discussion of stellar distances is instructive. The visible part of our Milky Way Galaxy is about 100,000 light years across and where we are it is about 1000 light years thick. You can use an example where the distance across our Solar System is a bit bigger than a quarter (with the Sun as a grain of sand in the center of the quarter) and the NEAREST star (4 light years away) is 2 football-field lengths away. The Milky Way Galaxy would span the United States (about 2500 miles) and be about 25 miles thick – about the same relative dimensions as a CD (100 to 1). To imagine the 200 billion stars in our Galaxy, think of building a four-foot high wall all around a football field and then filling it with birdseed. That's roughly 200 billion bird seeds. Now imagine distributing those seeds (stars) over the entire USA, 25 miles deep. The stars are VERY far apart!


Milky Way Galaxy dimensions are like a CD

- If the participant has heard of the Voyager missions from the 1970's, these spacecraft have passed well beyond the orbit of Pluto. Many people think these spacecraft are now "among the stars". On the slightly-larger-than-quarter-sized model of our Solar System, The Voyager spacecraft are only about 2-3 inches beyond the edge of the quarter – still VERY far from even the nearest star.

Background Information

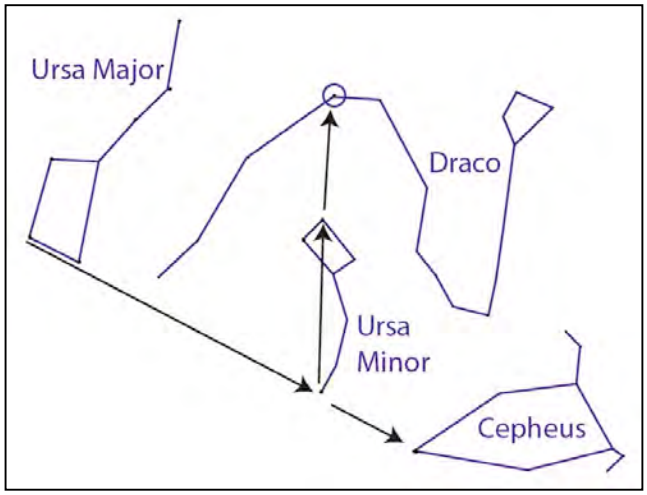
- **Planet Naming Conventions**:

  You may have noticed that the planets around a star are named b, c, d, as in gamma Cephei b, or Upsilon Andromeda b, Upsilon Andromeda c, and so on.

  You may have wondered why there is no "a" planet. As premier extra-solar planet hunter Debra Fisher explains it:
  "The "A" component is reserved for the star. The default naming convention (since the IAU hasn't jumped in) is that the first detected planet is "b" continuing alphabetically. Usually, the first detected planet is the inner one (Keplerian biases) but in one case, GJ 876, the outer planet was discovered first. So GJ 876 b is the outer planet, and GJ 876 c is the inner planet."
  (The IAU is the Internal Astronomical Union and is the organization that performs such tasks as setting naming conventions of astronomical objects.)

  Note also that when there is a binary star, the two stars are called, for example, Sirius A and Sirius B. The upper case A or B refers to stars. Lower case b, c, etc. refers to the planets.

- **Finding the brightest stars with planets**



The two brightest Northern Hemisphere stars with planets are gamma Cephei and iota Draconis. Fortunately they are visible almost all year and are fairly easy to find, even though they are only about 3rd magnitude. Note in the figure that you can use the pointer stars from the Big Dipper to point to the North Star (Polaris) and then just continue on another 20 degrees or so to gamma Cephei. Iota Draconis is found by starting at the North Star, drawing a line through the star at the "bottom" of the Little Dipper and continuing on to iota Draconis.

For more information on locations of distant worlds and for a 3-D interactive of where the distant worlds are:
http://planetquest1.jpl.nasa.gov/atlas/atlas_index.cfm

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The reverse side of the Planetary PostCards can be copied and used for any education and public outreach use.
You may want to change the reverse side of the cards to include your club's information if you want to use them as handouts at star parties.

Suggested Discussion Questions for Planetary PostCards

That star is hotter/colder than our Sun. How do you think that might affect its planets?

Here is where one of the planets orbits that star. What would it be like to live on this planet (or one of its moons)?

If Earth was orbiting that star, what might be different?

How big do you suppose this planet is compared to the planets in our Solar System?

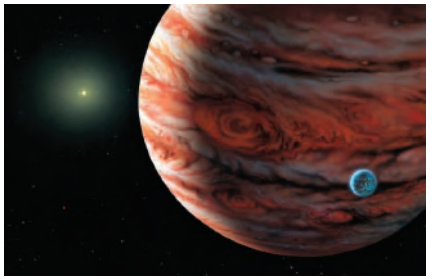
Do you think we have found all the planets in this system?

Our fastest spacecraft travels 42 miles per second. It would take 5,000 years for that spacecraft to go one light year. How long would it take to reach this star which is _____ light years away?

How different do you think Earth will be in that period of time?

PLANET QUEST the search for another Earth

Planetary PostCards



Artist: Lynette Cook 55 Cancri System

Abbreviations and terms used on PostCards

RA = Right Ascension

Dec = Declination

mag = apparent visual magnitude

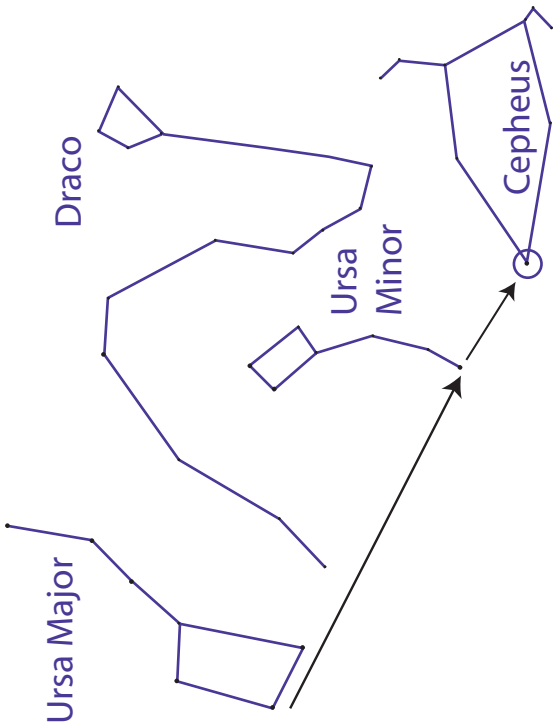
AU = Astronomical Unit, the distance between the Earth and the Sun: 93 million miles or 150 million km

Light year = The distance light travels in a year. Light travels at 186,000 miles per second or 300,000 km per second. Light from the Sun takes 8 minutes to reach Earth.

Jupiter mass = 1.9×10^{27} kg. Jupiter is about 300 times more massive than Earth (approximate difference between a large bowling ball and a small marble)

Temperature of the stars is in degrees Celsius

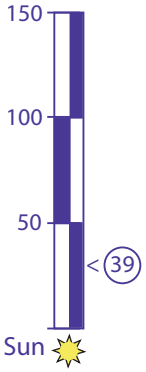
gamma Cephei



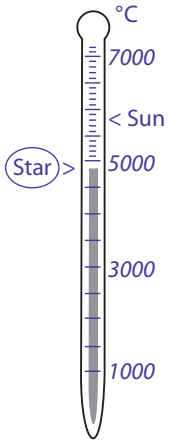
RA: 23h 39m
Dec: 77° 39'
mag: 3.2

Star: Gamma Cephei

How far in light years?



How Hot?

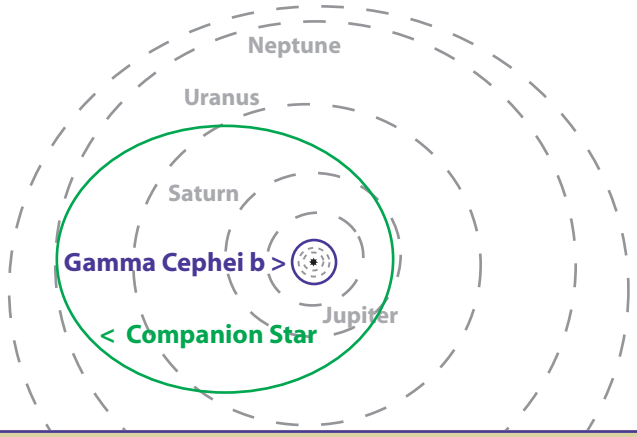


The brightest star with a planet is a Binary star AND it's a Red Giant!

Its small "companion star" gets as close as 12 AU in a 40-year orbit.

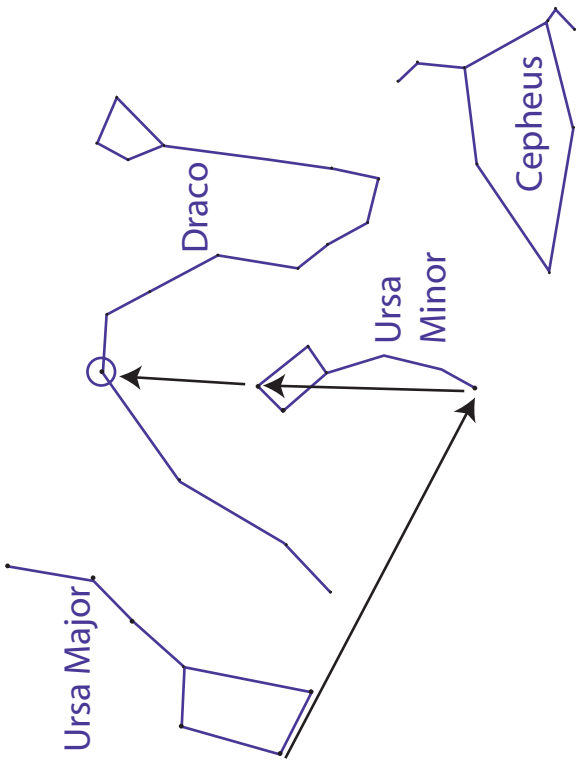
Planet: Gamma Cephei b

Star's System Compared to Our Solar System



Planet (year discovered):	b (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	2 AU
Orbit:	2.5 years
Mass:	1.8 Jupiters

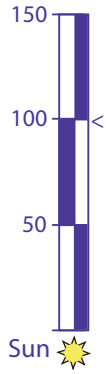
Iota Draconis



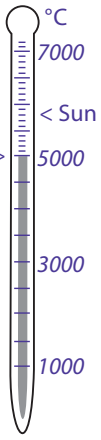
RA: 15h 24m
Dec: 58° 57'
mag: 3.3

Star: Iota Draconis

How far in light years?

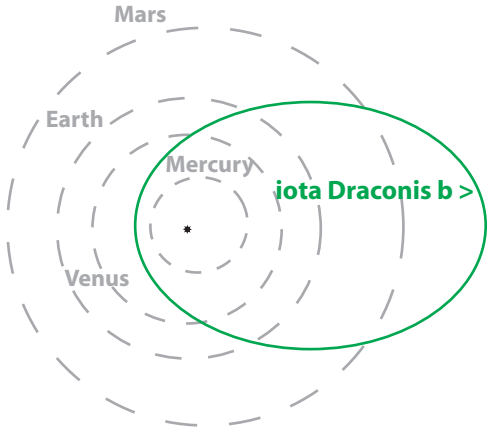


How Hot?



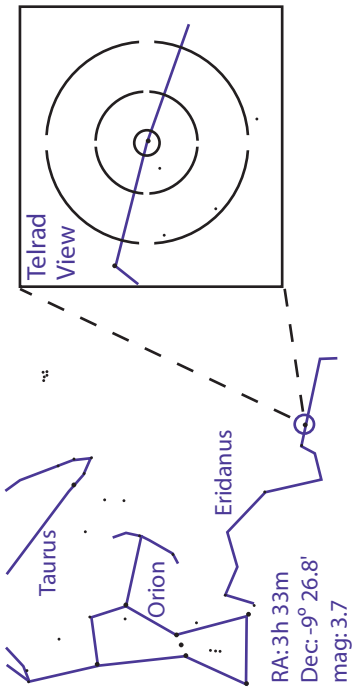
Planet: Iota Draconis b

Star's System Compared to Our Solar System

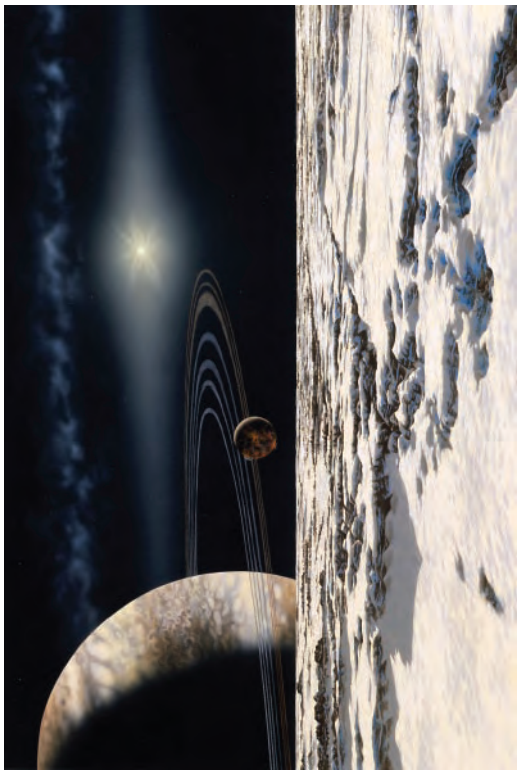


Planet (year discovered):	b (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	1.3 AU
Orbit:	1.5 years
Mass:	8.7 Jupiters(!)

Epsilon Eridani

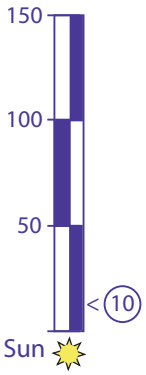


View from a frozen moon of the "b" planet, with a smaller volcanic moon closer to the planet. Also shows a possible dust ring around the star.

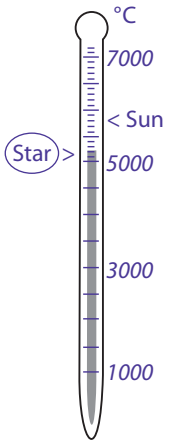


Star: Epsilon Eridani

How far in light years?



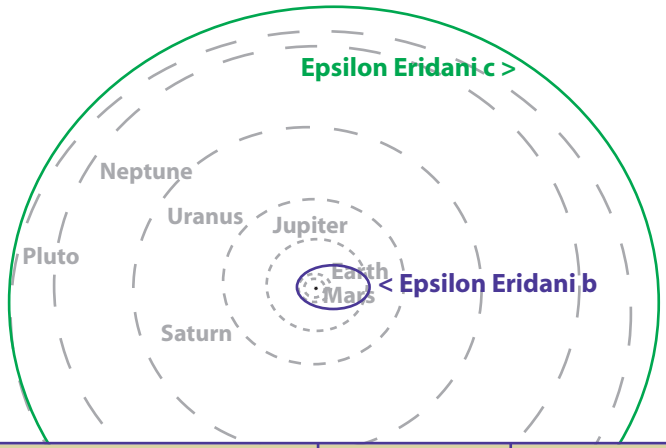
How Hot?



This is the closest star to us with known planets. Our fastest spacecraft would take 50,000 years to reach this star system.

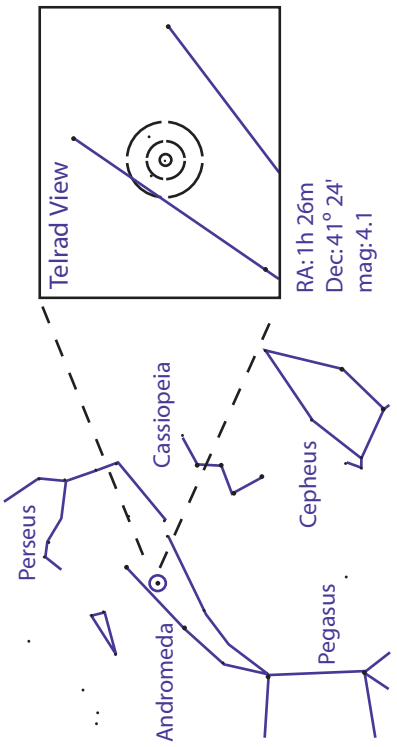
Planet: Epsilon Eridani b and c

Star's System Compared to Our Solar System

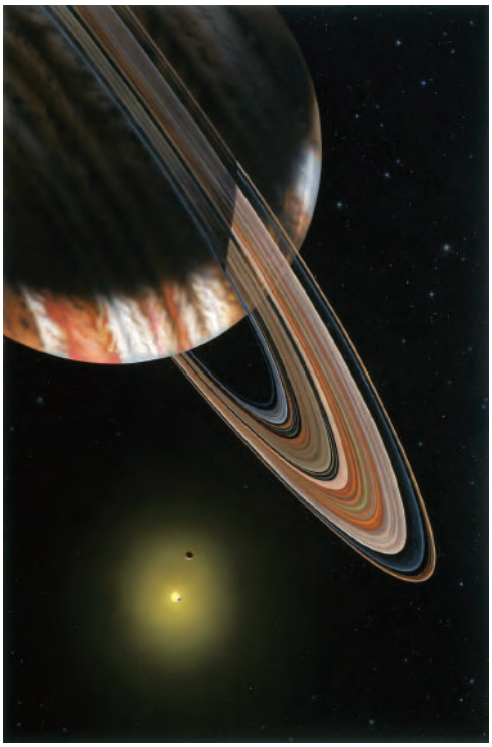


Planets (year discovered):	b (2000)	c (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	3.3 AU	40 AU
Orbit:	6.8 years	260 years
Mass:	90% of Jupiter	10% of Jupiter

Upsilon Andromedae

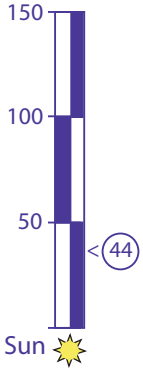


Shows all three known planets – the outer and most massive planet is shown with a ring like Saturn's.

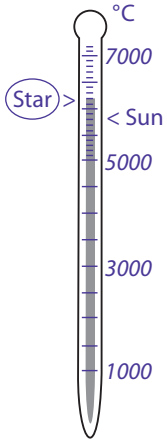


Star: Upsilon Andromedae

How far in light years?



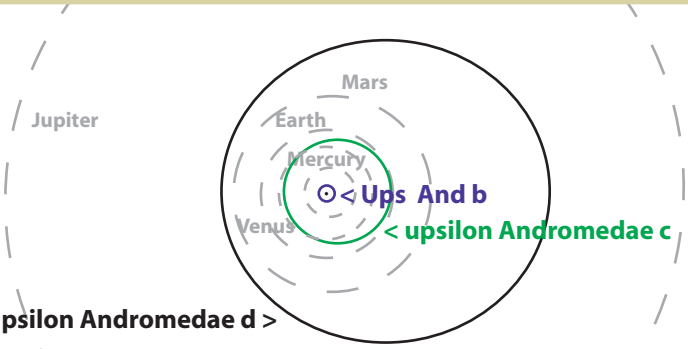
How Hot?



This is the first star discovered with a confirmed multi-planet system. Planet b was discovered in 1996 and c & d in 1999.

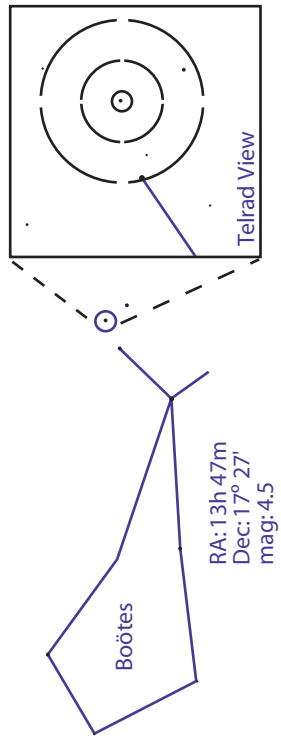
Planet: Upsilon Andromedae b, c, and d

Star's System Compared to Our Solar System



Planets (year discovered):	b (1996)	c (1999)	d (1999)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.06 AU	0.83 AU	2.5 AU
Orbit:	4.6 Days	8 Months	3.5 Years
Mass:	71% Jupiter	2.1 Jupiters	4.6 Jupiters

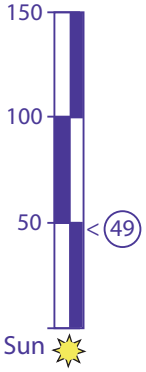
Tau Bootis



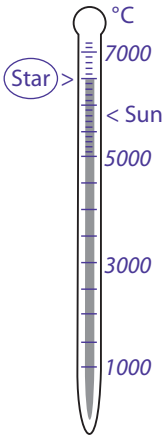
View of the Jupiter-like planet with its star in the background.

Star: Tau Bootis

How far in light years?



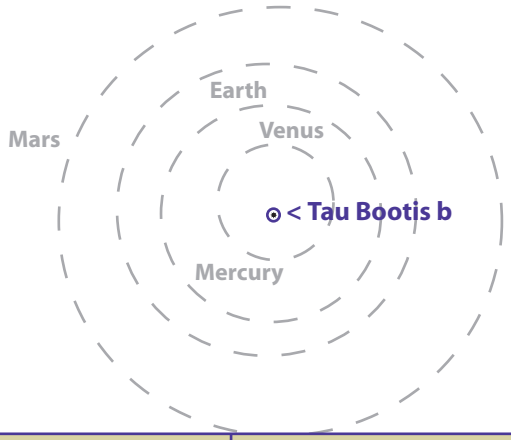
How Hot?



This huge planet is orbiting so close to its star and its star is so hot, this may be the hottest planet yet discovered!

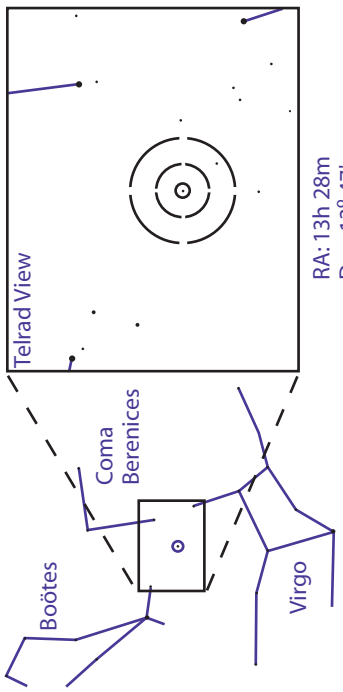
Planet: Tau Bootis b

Star's System Compared to Our Solar System

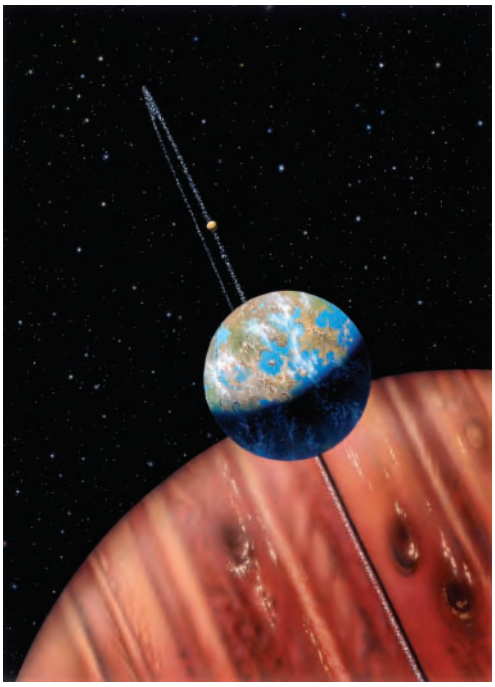


Planet (year discovered):	b (1996)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.05 AU
Orbit:	3.3 days
Mass:	3.9 Jupiters

70 Virginis

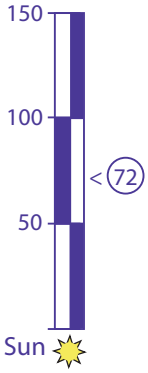


The planet is shown with a ring and two moons. A small, gold moon and the other moon resembling Earth.

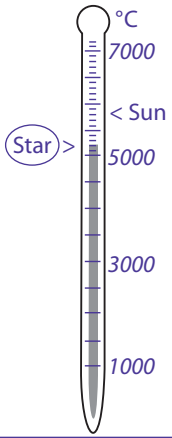


Star: 70 Virginis

How far in light years?



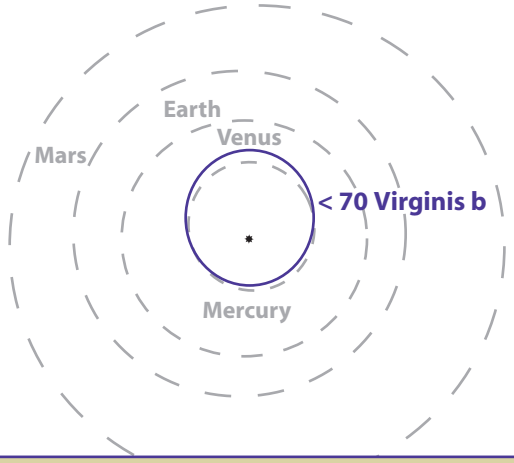
How Hot?



This massive planet is orbiting a star cooler than the Sun. It may have moons with liquid water. The planet is shown on the front with a ring and two moons. One moon is shown resembling Earth, having oceans and land.

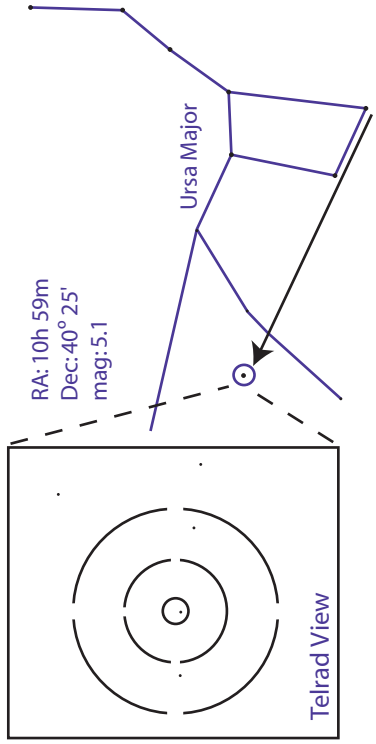
Planet: 70 Virginis b

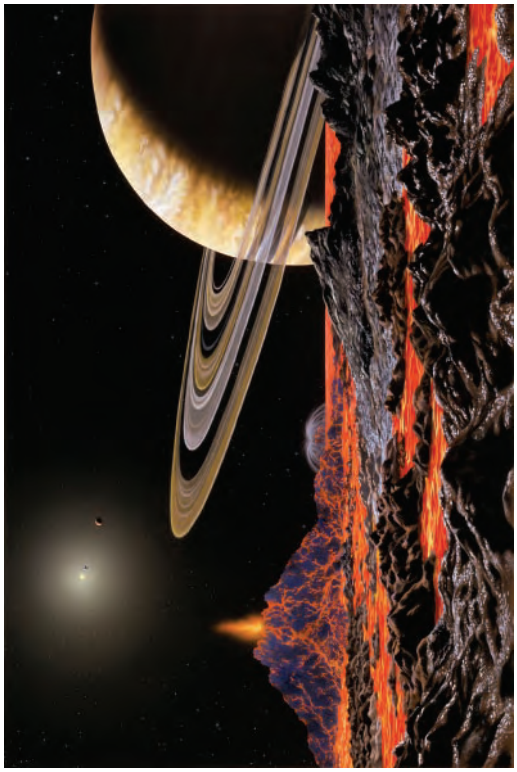
Star's System Compared to Our Solar System



Planet (year discovered):	b (1996)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.4 AU
Orbit:	117 days
Mass:	6.6 Jupiters

47 Ursae Majoris

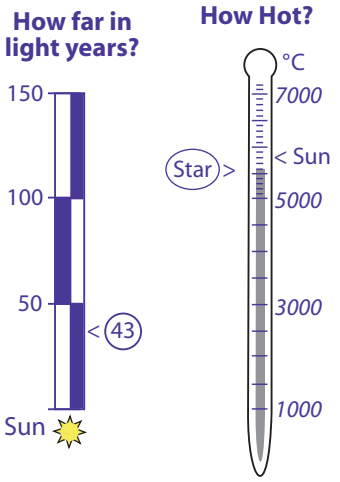




View from a possible moon of the outermost planet. Also shown: the confirmed inner planet and a possible "water world" close to the star.

Star: 47 Ursae Majoris

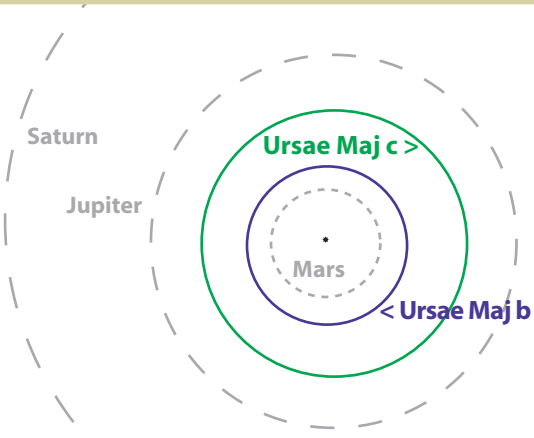
Same Size as Our Sun



Two giant planets are orbiting in nearly circular orbits far from their star. This system is somewhat like our Solar System. Might rocky planets like Earth exist closer to the star?

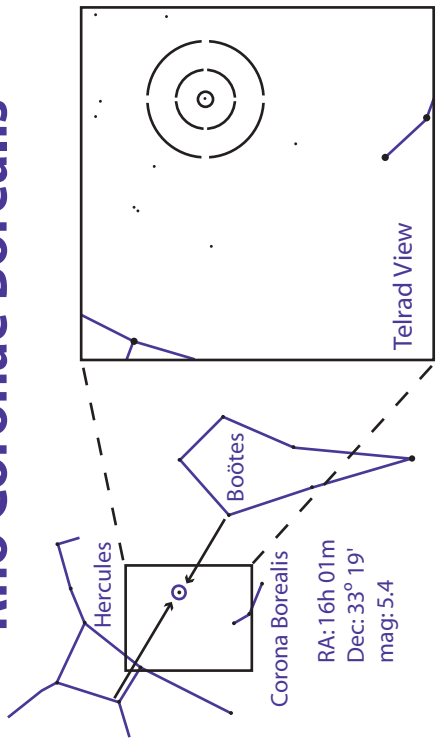
Planets: 47 Ursae Majoris b and c

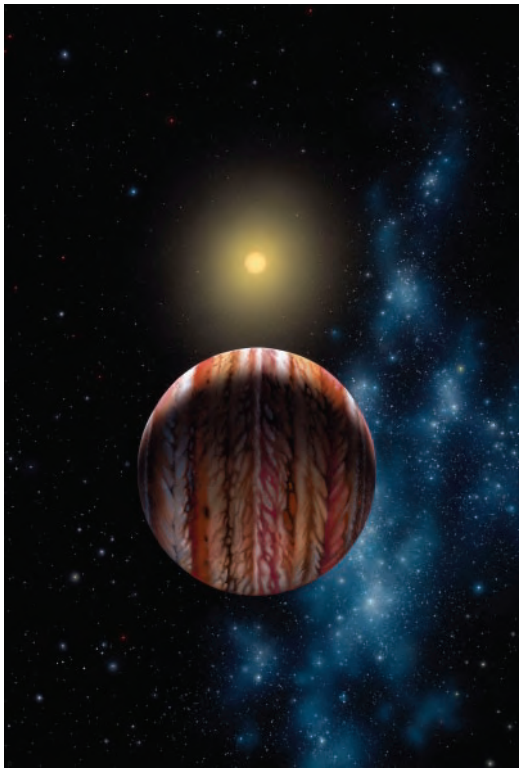
Star's System Compared to Our Solar System



Planets (year discovered):	b (1996)	c (2001)
Avg Distance From Star: (Earth from Sun = 1 AU)	2.1 AU	3.7 AU
Orbit:	3 years	7.1 years
Mass:	2.4 Jupiters	76% of Jupiter

Rho Coronae Borealis

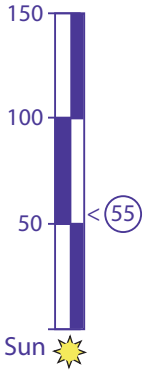




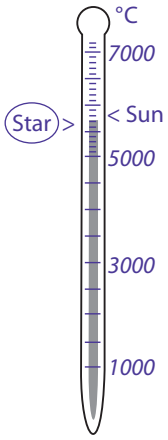
Jupiter-like planet orbits its star at about the same distance as Mercury orbits the Sun.

Star: Rho Coronae Borealis

How far in light years?



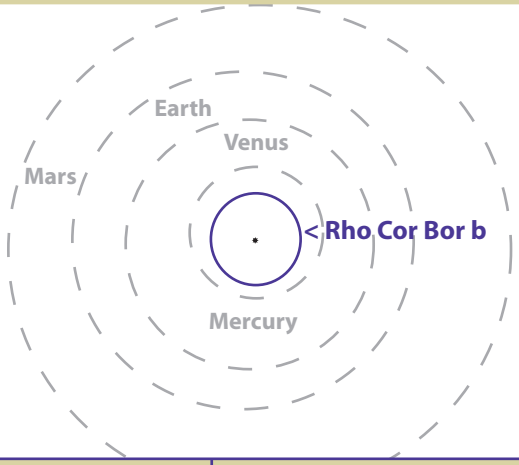
How Hot?



A belt of rocky/icy objects appears to orbit this star at about the same distance as the Kuiper Belt from our Sun. The occasional comet may appear in skies of this star's planet(s).

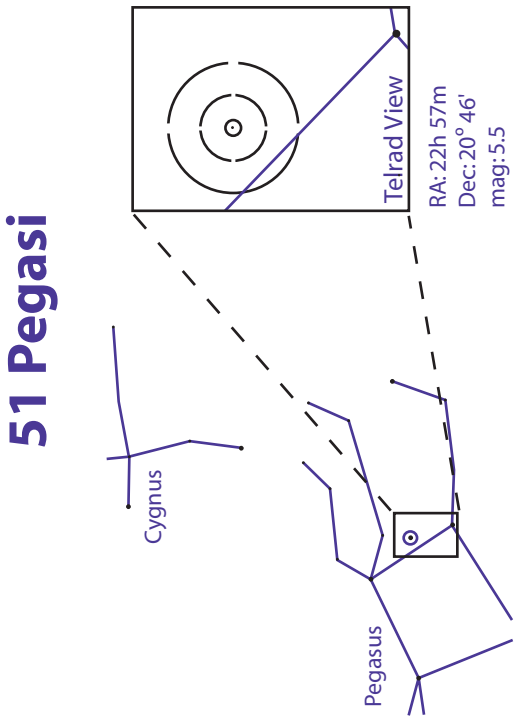
Planet: Rho Coronae Borealis b

Star's System Compared to Our Solar System



Planet (year discovered):	b (1997)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.23 AU
Orbit:	39.6 days
Mass:	1.1 Jupiters

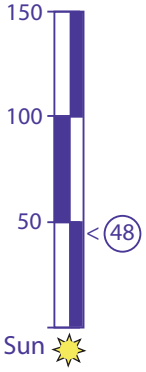
51 Pegasi



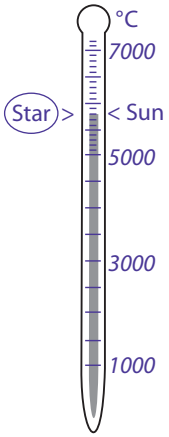
The "hot Jupiter" orbiting very close to its star.

Star: 51 Pegasi

How far in light years?



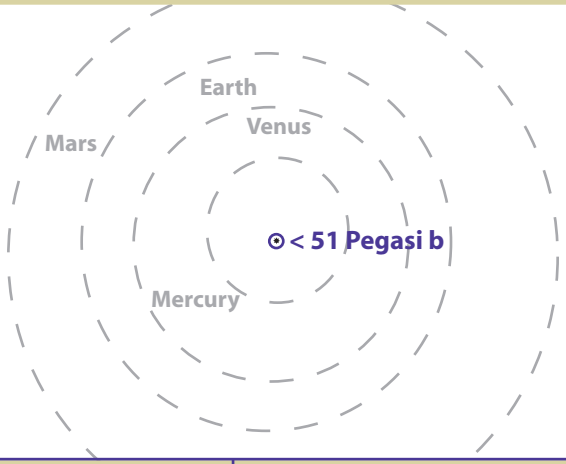
How Hot?



This star was the FIRST sun-like star discovered to have a planet – in 1995, the first evidence that other stars like our Sun have planetary systems.

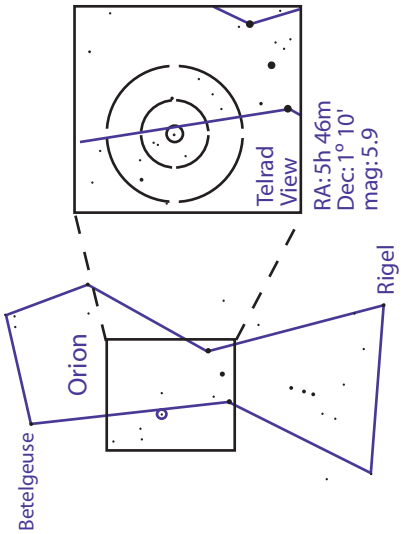
Planet: 51 Pegasi b

Star's System Compared to Our Solar System



Planets (year discovered):	b (1995)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.05 AU
Orbit:	4.2 days
Mass:	50% of Jupiter

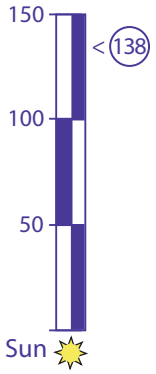
HD 38529 (Orion)



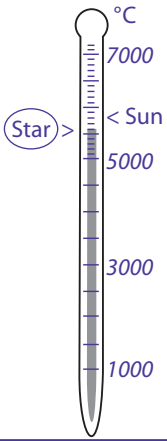
View from the surface of a hypothetical icy moon of the outermost planet, which is shown with rings and two other moons.

Star: HD 38529 (Orion)

How far in light years?



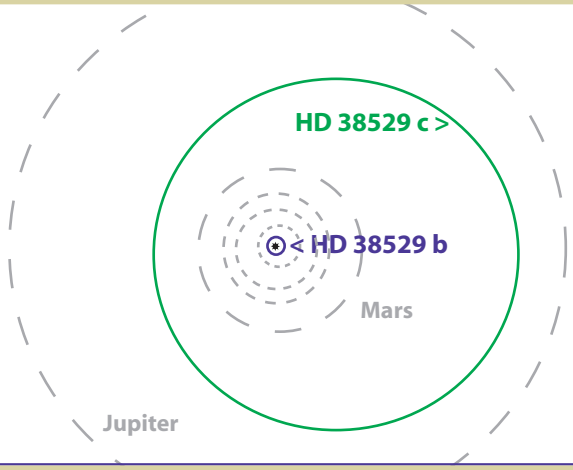
How Hot?



This star is very dim – it is about how bright our Sun would look from the distance of this star. Compare this "small" star to Orion's Betelgeuse – a red giant over 400 light years away or Rigel – a blue hot supergiant at over 750 light years.

Planets: HD 38529 b and c

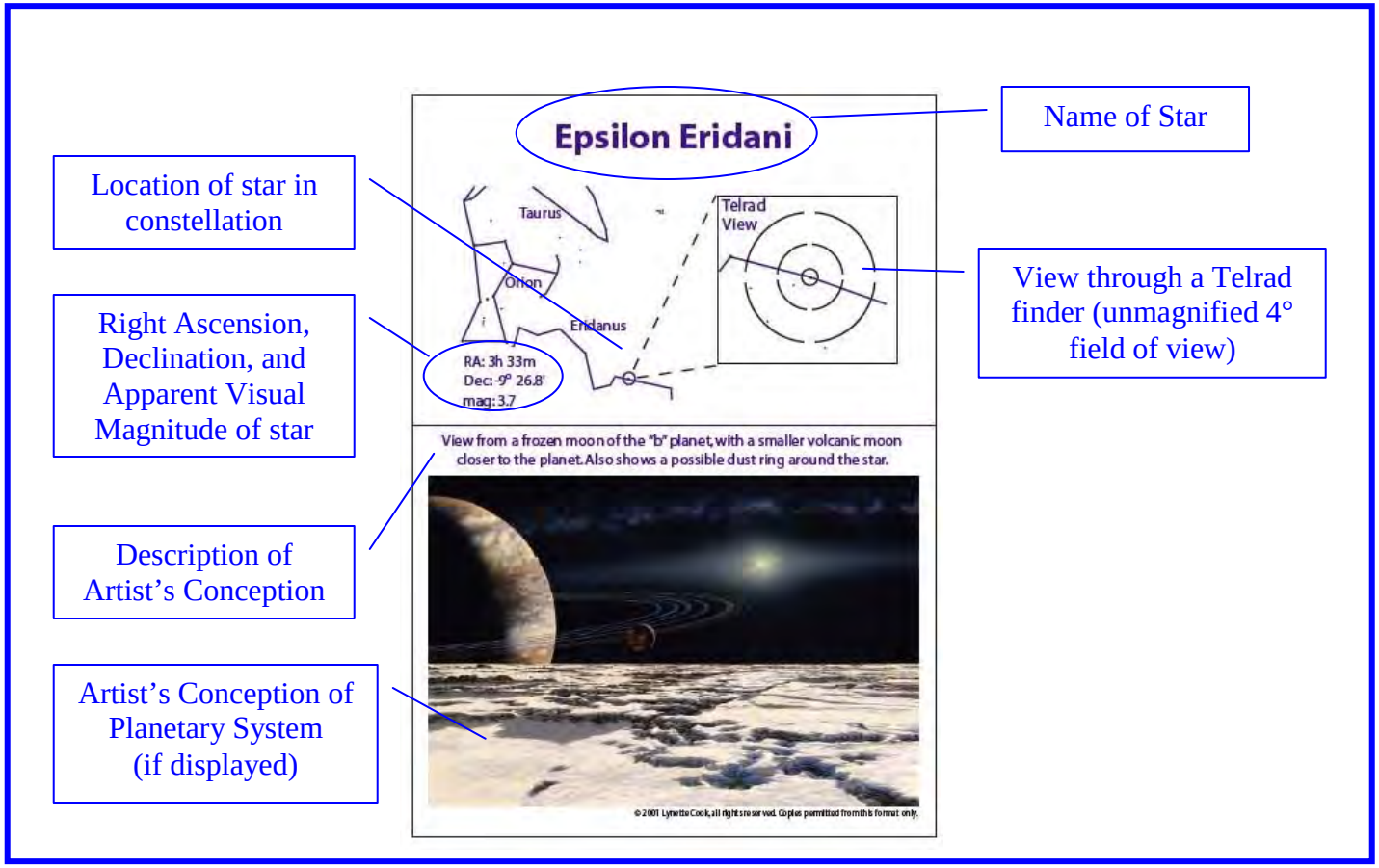
Star's System Compared to Our Solar System



Planets (year discovered):	b (2000)	c (2002)
Avg Distance From Star: (Earth from Sun = 1 AU)	0.12 AU	3.5 AU
Orbit:	14.4 days	6 years
Mass:	77% of Jupiter	11.3 Jupiters

Planetary PostCards Key

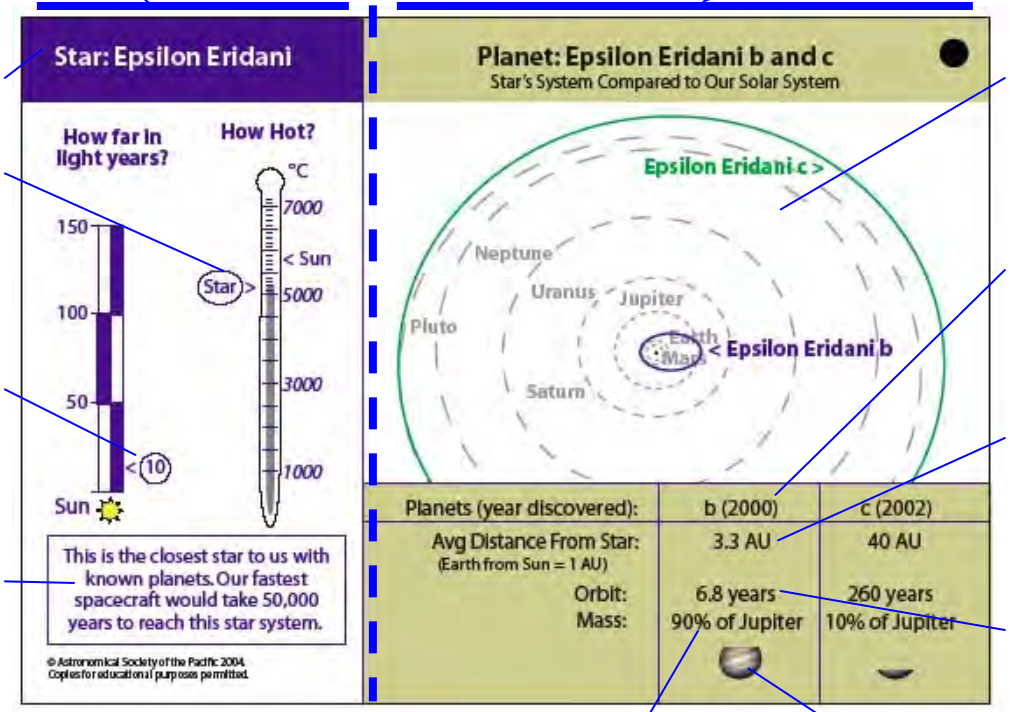
FRONT



BACK

INFORMATION ABOUT THE STAR

INFORMATION ABOUT THE STAR'S PLANETS



Name of the Star

Star's temperature compared to the Sun's temperature in Celsius

Star's Distance from the Sun in Light Years

Fun fact about the star and/or its planets

Orbits of the star's planets compared to the orbits of the Sun's planets

Planet's name (b, c, etc.) and the year it was discovered

Average distance of the planet from its star in Astronomical Units (AU = distance from Earth to Sun)

Period of the planet's orbit in Earth years or days

Mass of the planet compared to Jupiter's mass (Jupiter is 300 times the mass of Earth)

Icon(s) representing the planet's mass in Jupiters

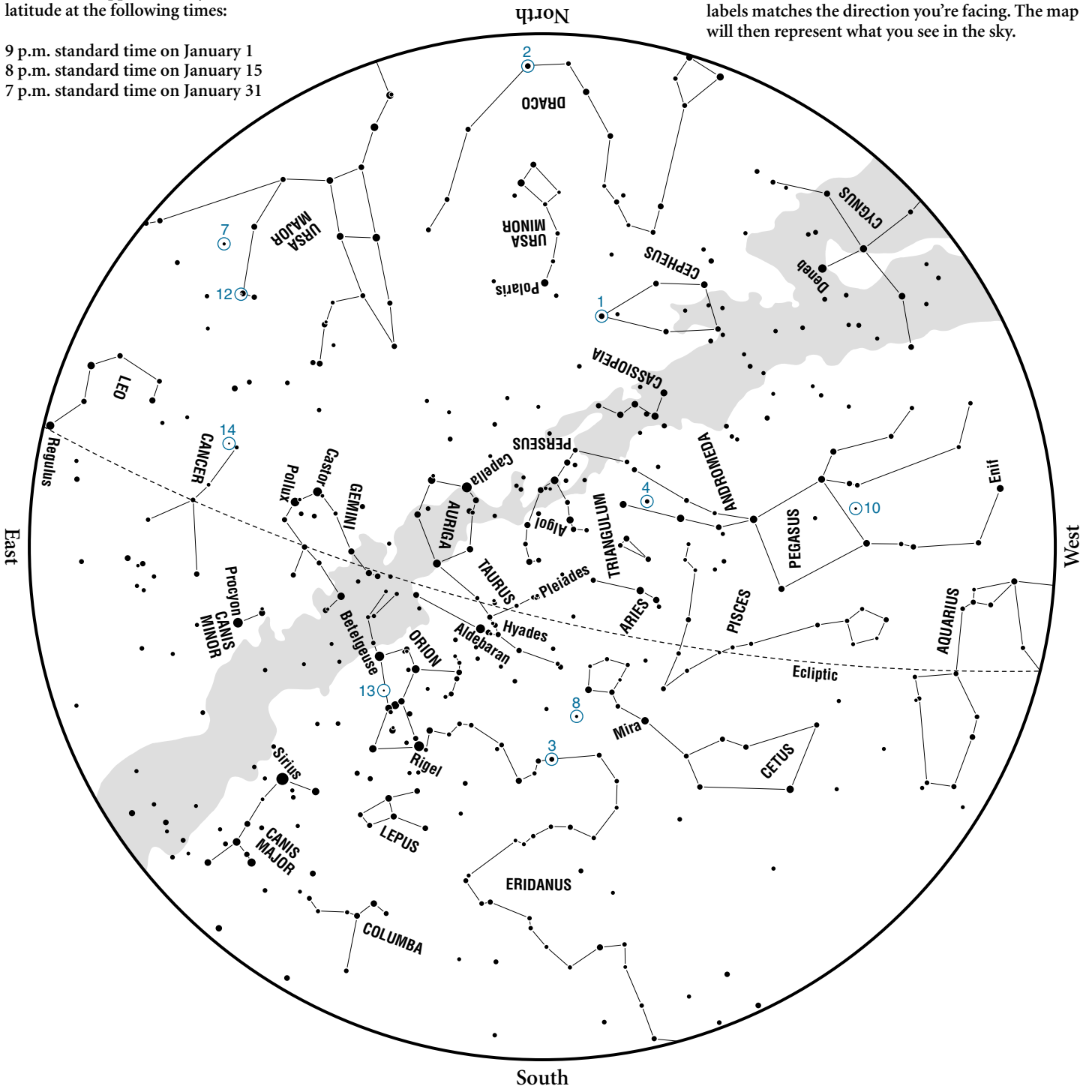
Where are the Distant Worlds?

January

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on January 1
8 p.m. standard time on January 15
7 p.m. standard time on January 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



Stars visible to the unaided eye known to have planets — listed brightest to dimmest (stars visible this month are circled and numbered on the map)

(1) – Gamma Cephei
(2) – Iota Draconis
(3) – Epsilon Eridani
(4) – Upsilon Andromedae
5 – Tau Bootis
6 – 70 Virginis
(7) – 47 Ursae Majoris
(8) – HD 19994 (Cetus)
9 – Rho Coronae Borealis
(10) – 51 Pegasi
11 – Gliese 777a (Cygnus)
(12) – HD 89744 (Ursa Major)
(13) – HD 38529 (Orion)
(14) – 55 Cancri

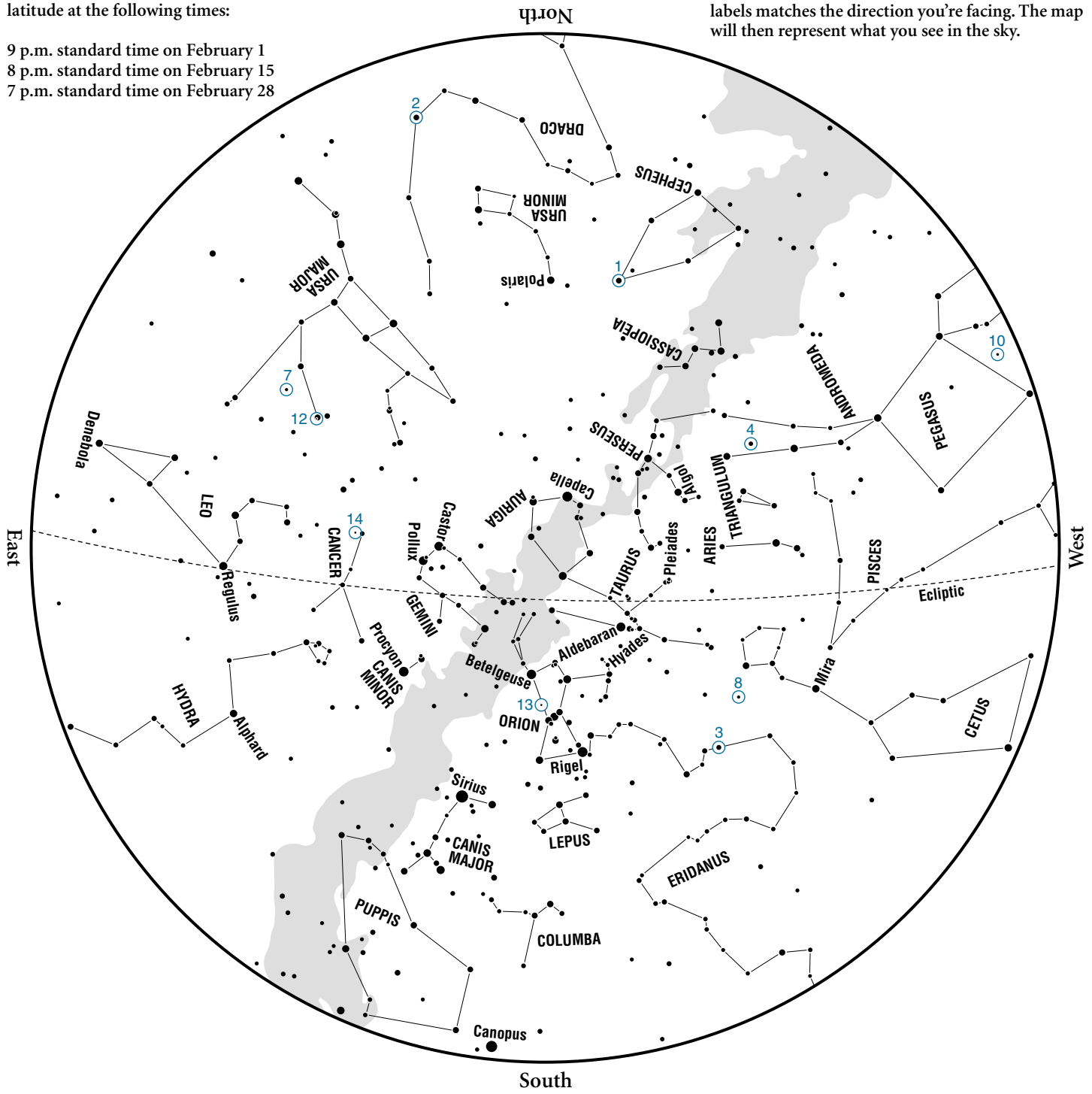
Where are the Distant Worlds?

February

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on February 1
8 p.m. standard time on February 15
7 p.m. standard time on February 28

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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(13) – HD 38529 (Orion)
(14) – 55 Cancri

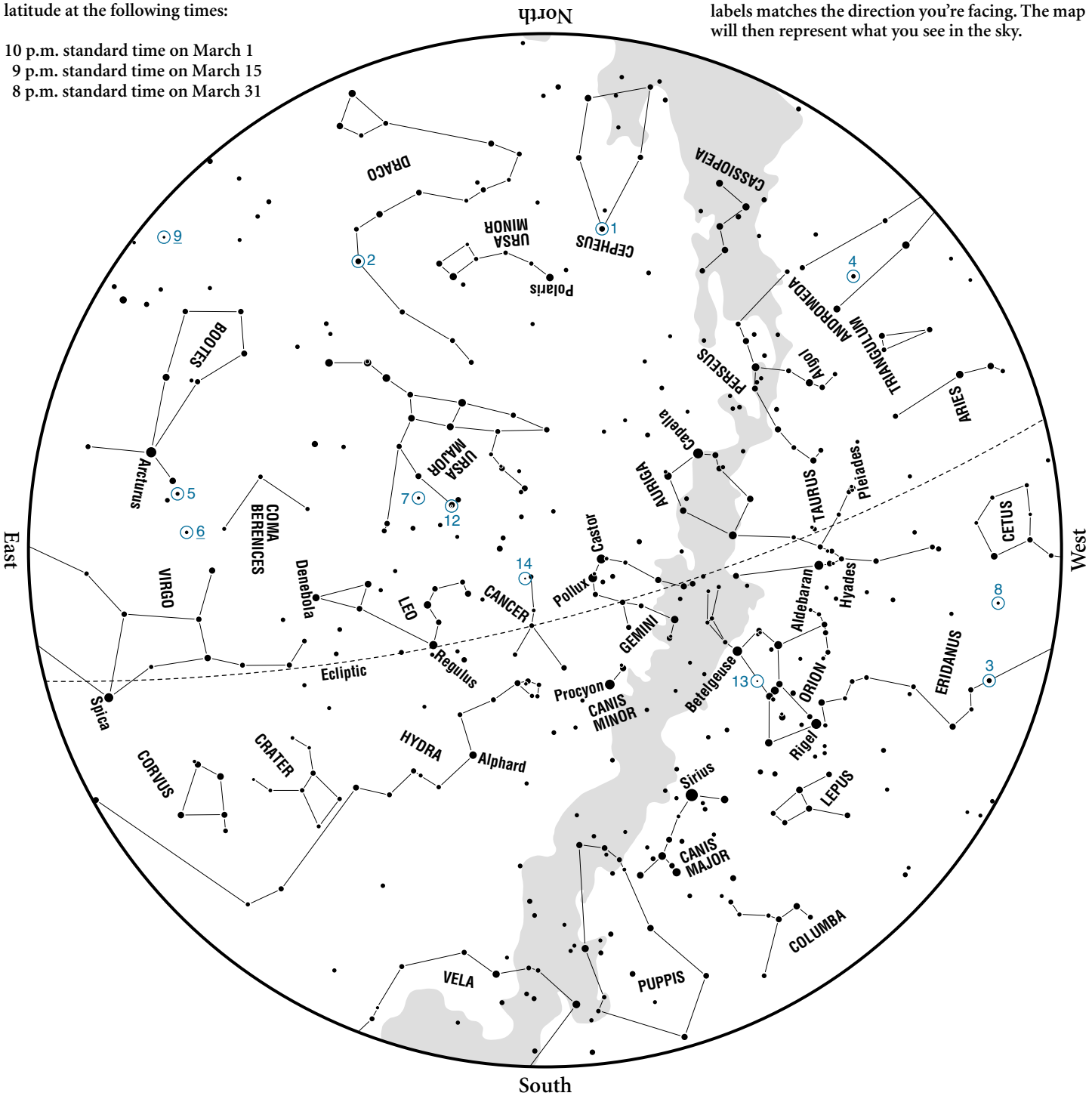
Where are the Distant Worlds?

March

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. standard time on March 1
9 p.m. standard time on March 15
8 p.m. standard time on March 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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11 – Gliese 777a (Cygnus)
12 – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
14 – 55 Cancri

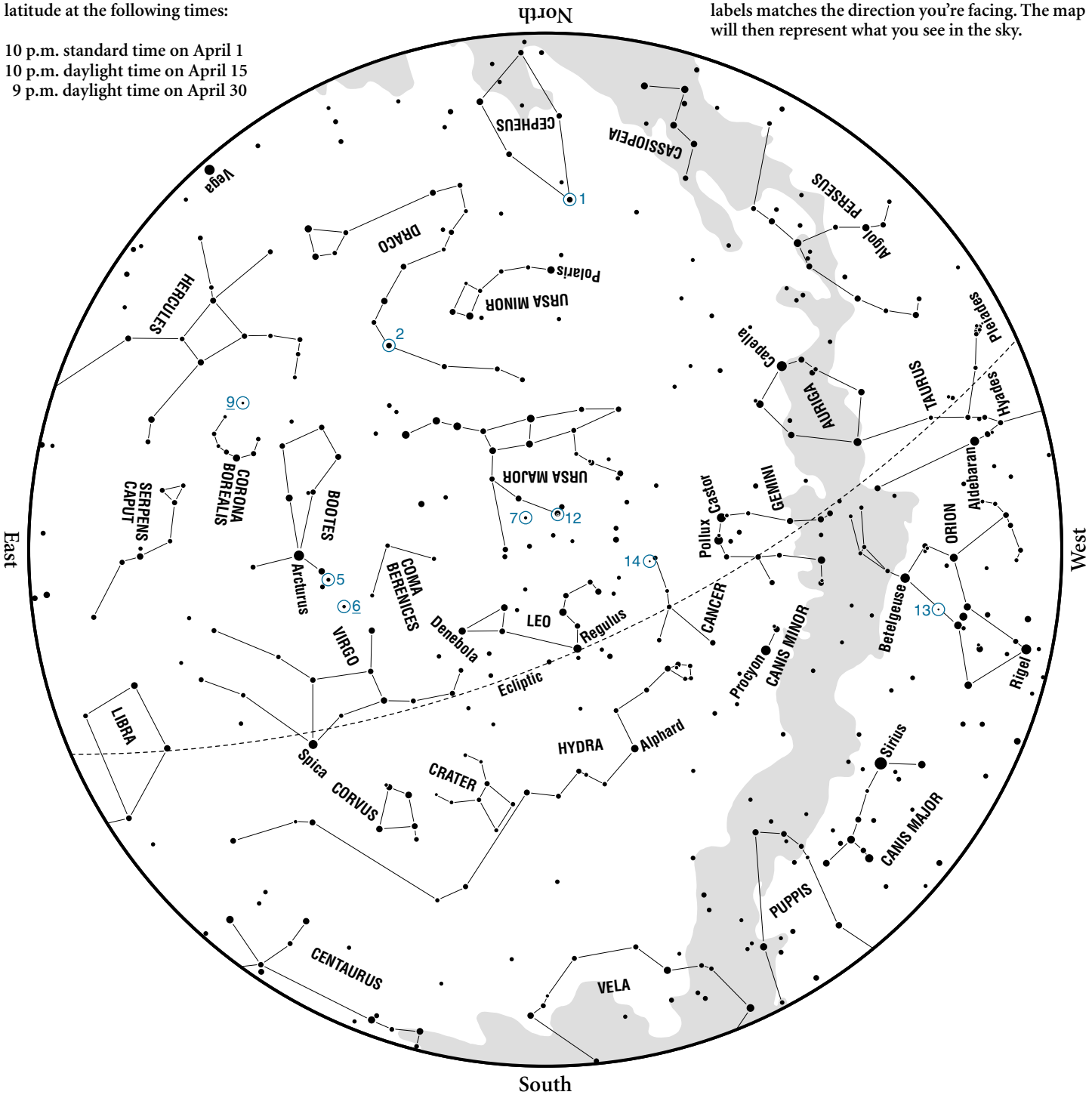
Where are the Distant Worlds?

April

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. standard time on April 1
10 p.m. daylight time on April 15
9 p.m. daylight time on April 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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(14) – 55 Cancri

 Map by Richard Talcott, senior editor, *Astronomy* magazine.

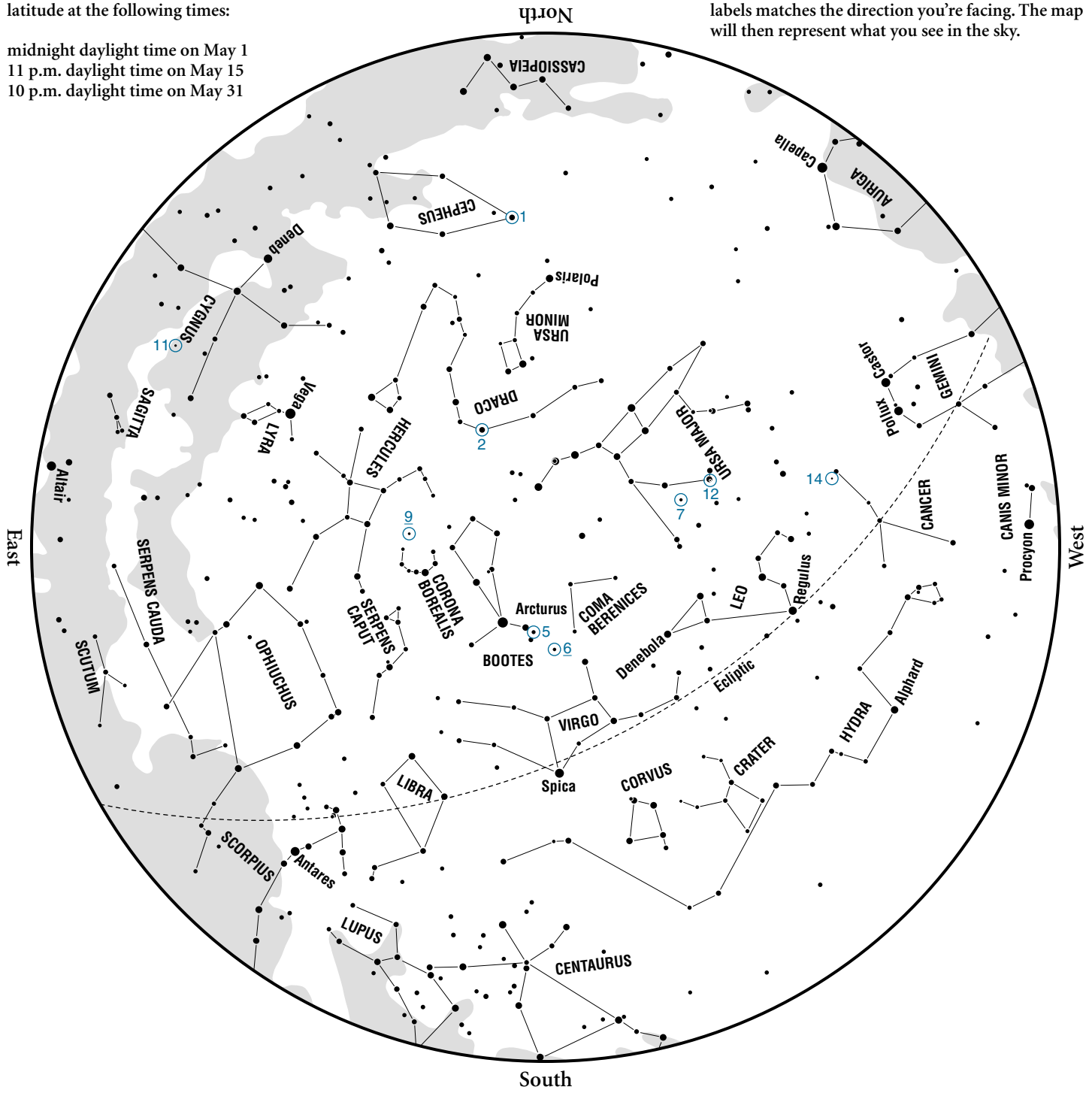
Where are the Distant Worlds?

May

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

midnight daylight time on May 1
11 p.m. daylight time on May 15
10 p.m. daylight time on May 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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(12) – HD 89744 (Ursa Major)
13 – HD 38529 (Orion)
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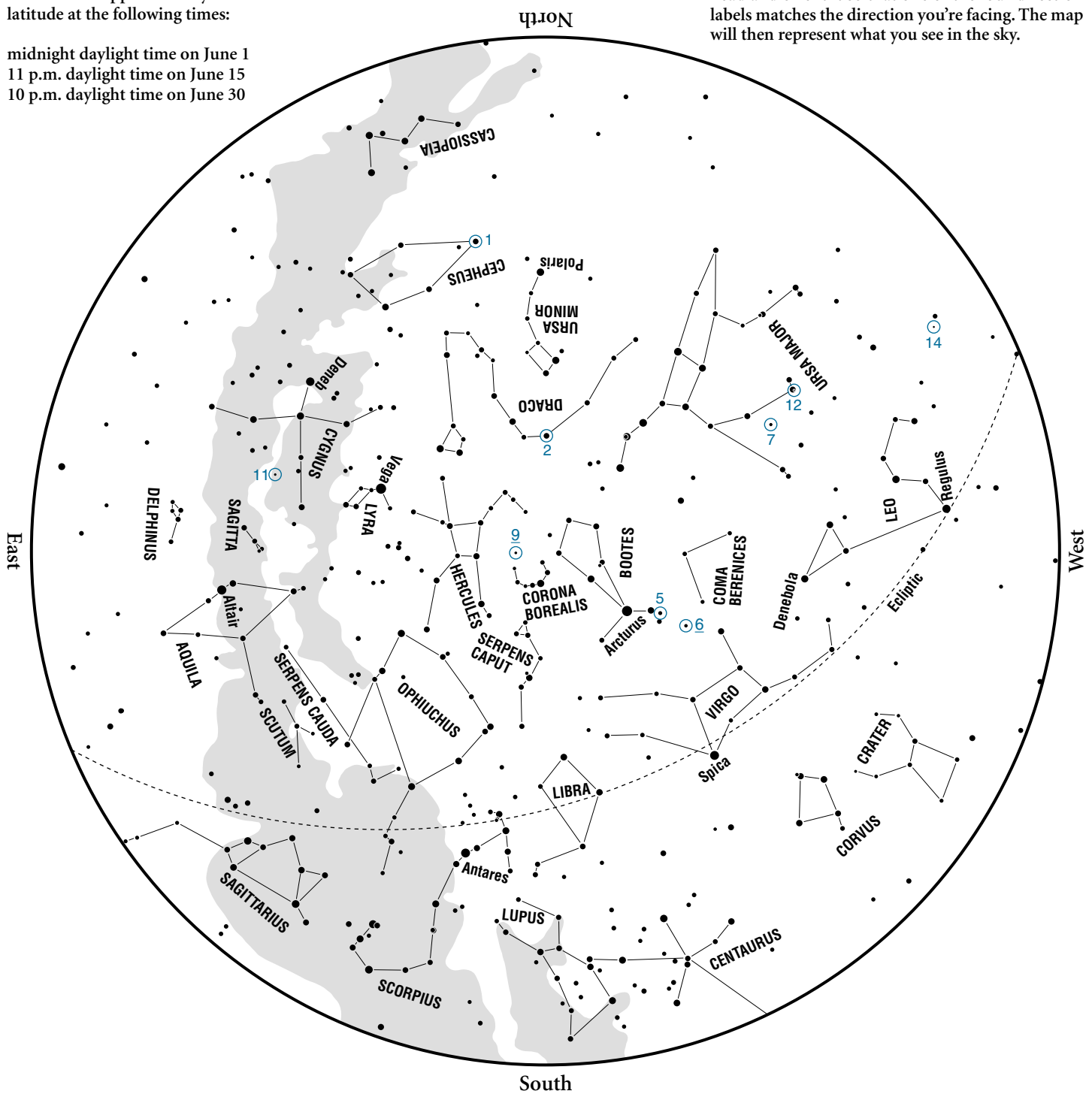
Where are the Distant Worlds?

June

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

midnight daylight time on June 1
11 p.m. daylight time on June 15
10 p.m. daylight time on June 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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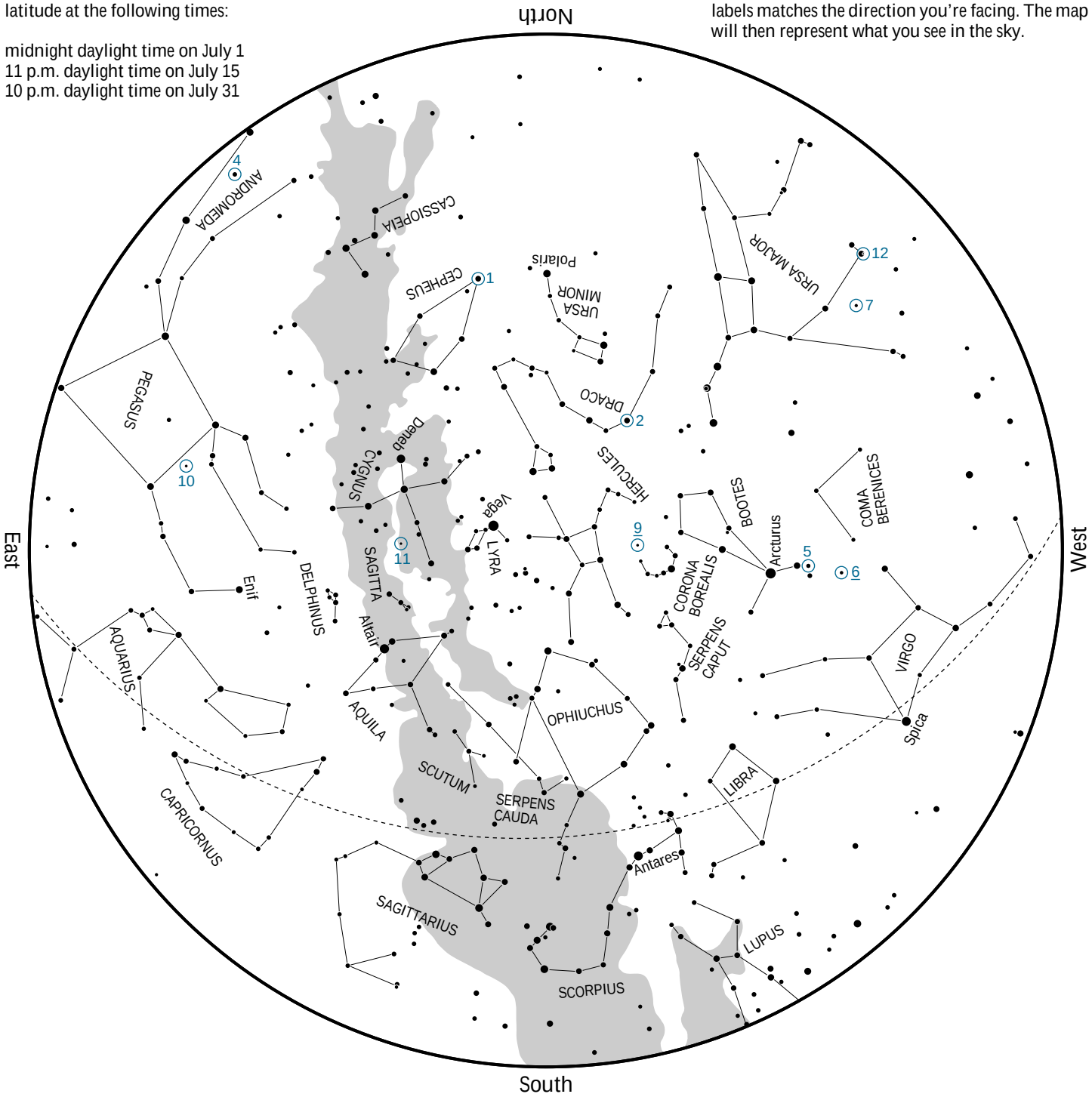
Where are the Distant Worlds?

July

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

midnight daylight time on July 1
11 p.m. daylight time on July 15
10 p.m. daylight time on July 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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13 – HD 38529 (Orion)
14 – 55 Cancri

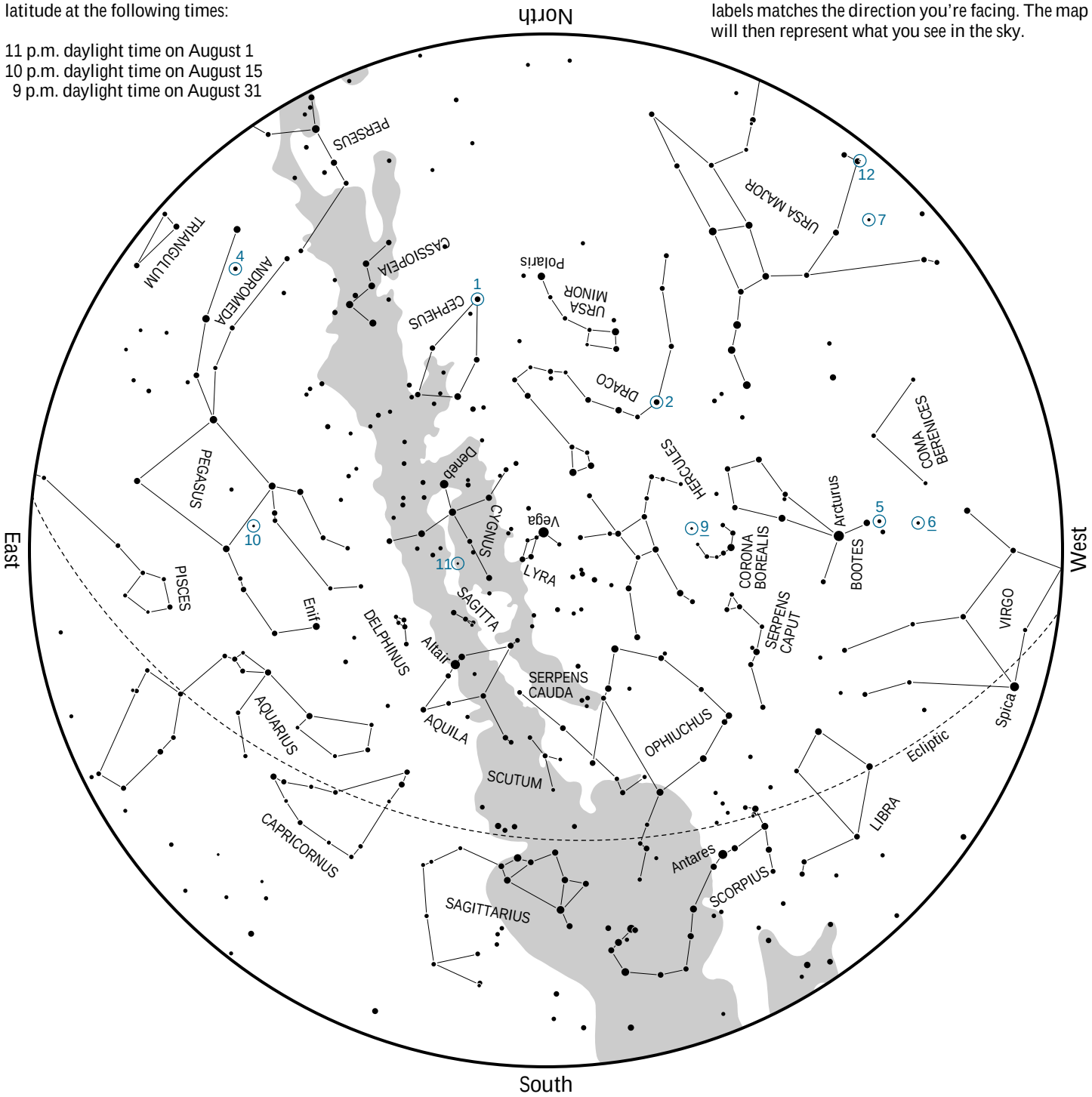
Where are the Distant Worlds?

August

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

11 p.m. daylight time on August 1
10 p.m. daylight time on August 15
9 p.m. daylight time on August 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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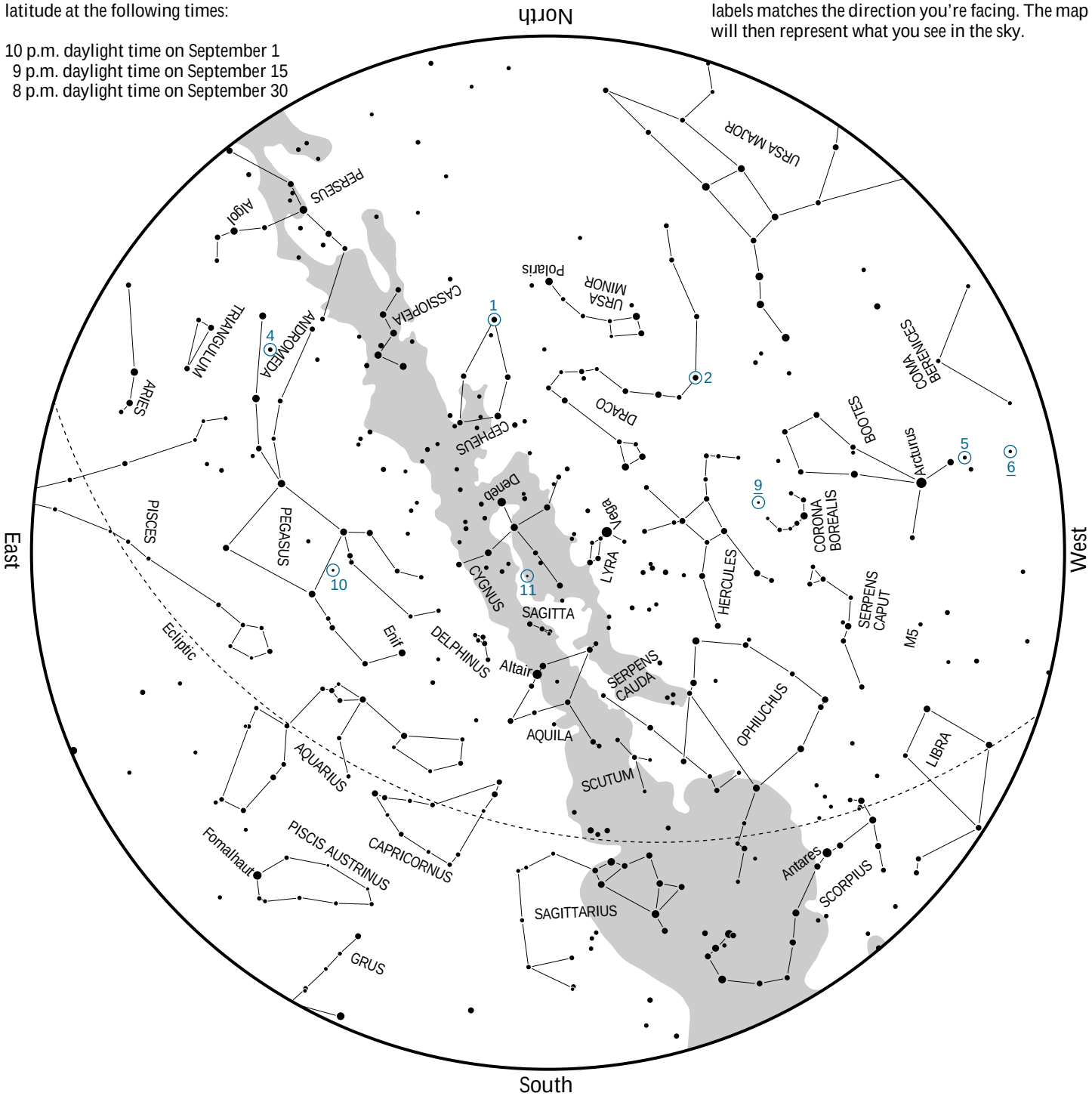
Where are the Distant Worlds?

September

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on September 1
9 p.m. daylight time on September 15
8 p.m. daylight time on September 30

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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14 – 55 Cancri

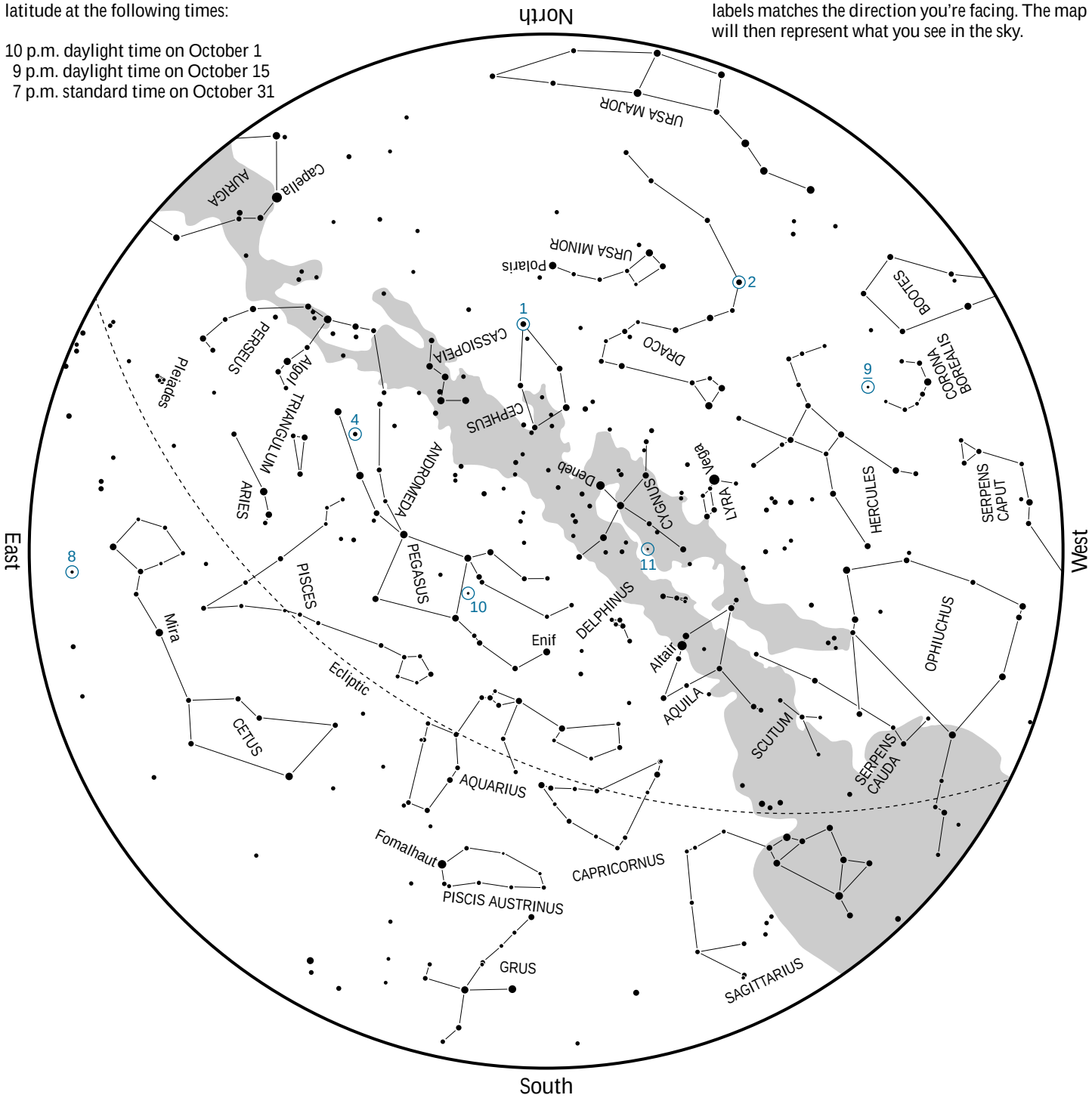
Where are the Distant Worlds?

October

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

10 p.m. daylight time on October 1
9 p.m. daylight time on October 15
7 p.m. standard time on October 31

To locate stars in the sky, hold the map above your head and orient it so that one of the four direction labels matches the direction you're facing. The map will then represent what you see in the sky.



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Where are the Distant Worlds?

November

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on November 1
8 p.m. standard time on November 15
7 p.m. standard time on November 30

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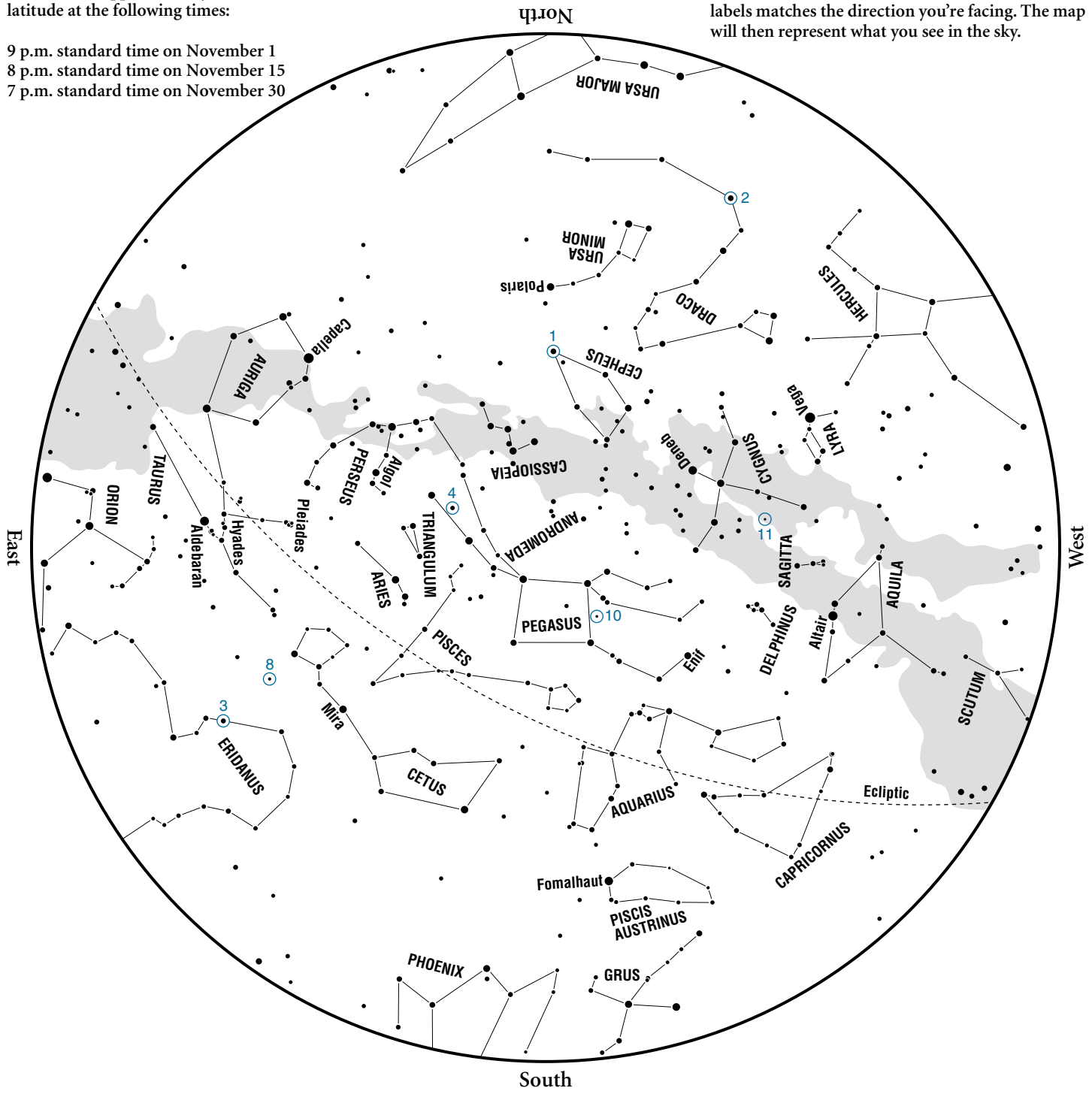

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Where are the Distant Worlds?

December

The all-sky map represents the night sky as seen from approximately 35° north latitude at the following times:

9 p.m. standard time on December 1
8 p.m. standard time on December 15
7 p.m. standard time on December 31

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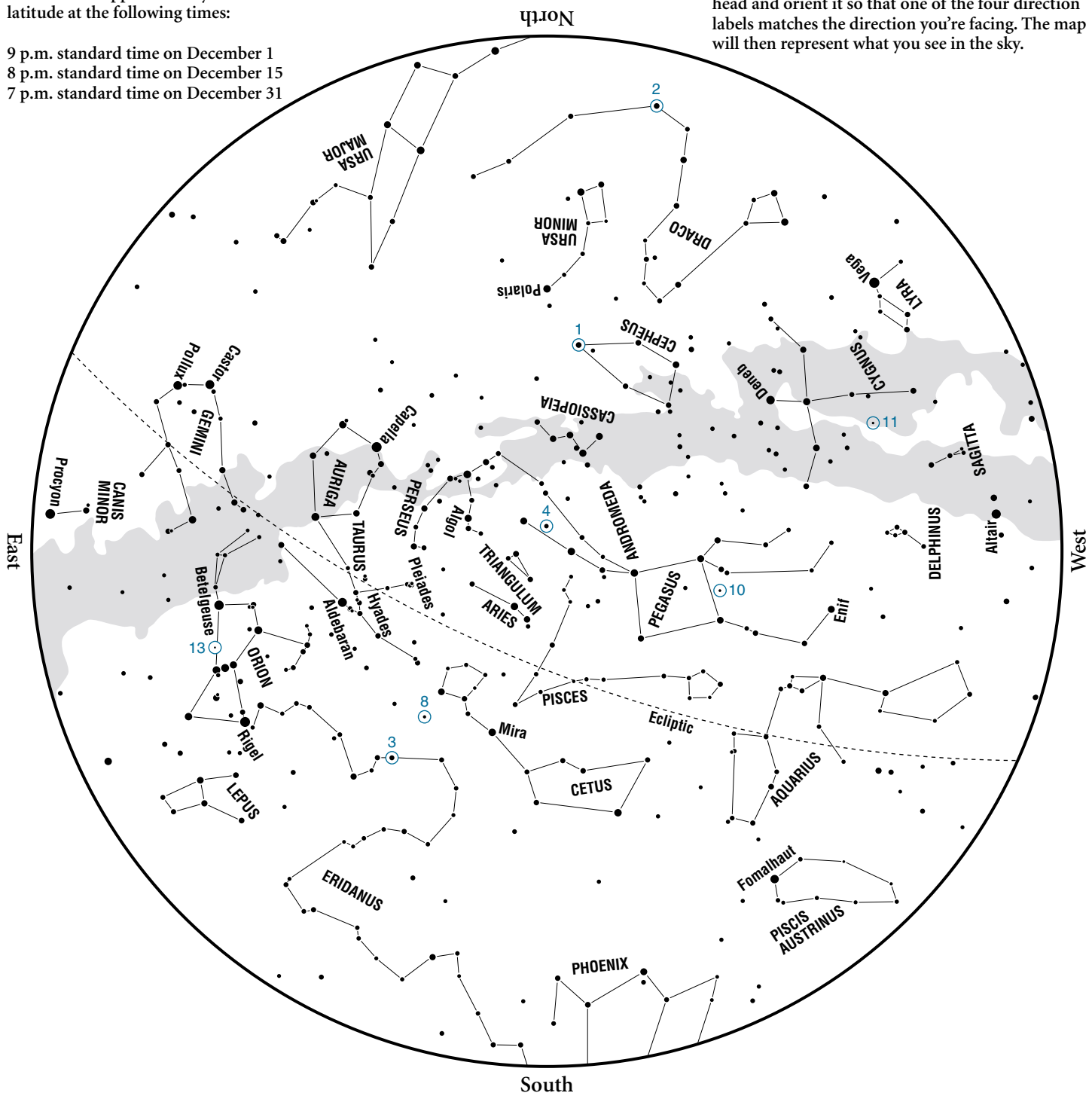

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Visible Stars with Planets (Brightest to Dimmest)

	Constell-ation	Host Star	Distance from Earth (light-years)	Appar-ent Mag.	Star data / Spec Type	Star Surface Temp (K) est.	Solar Masses / Solar Radii	Planets	Planet Mass (Jupiter=1)	Eccent ricity	Avg Dist from Star (AU)	Orbital Period
1	Cepheus	gamma Cephei	38.5	3.225	Binary 12 AU apart – 40 yr period / K1 IV RedGiant	4900	1.6 / 4.7	b	1.76	0.2	2	2.5 yrs
2	Draco	Iota Draconis	100	3.3	K2III RedGiant	4420	1.05 / 13	b	8.7	0.71	1.3	550.651 days
3	Eridanus	Epsilon Eridani	10.4	3.73	K2V	5180	0.85 / ?	b	0.86	0.6	3.3	2502.1 dys (6.85 yrs)
			10.4	3.73	K2V	5180	0.85 / ?	c	0.1	0.3	40	260 yrs
4	Andromeda	Upsilon Andromedae	43.9	4.09	F8V	6200	1.3 / 1.6	b	0.71	0.04	0.06	4.6 days
								c	2.11	0.23	0.83	242 days
								d	4.61	0.36	2.5	1266.6 dys
5	Bootes	tau Bootes	49	4.5	F7V	6300	1.2 / 1.2	**b**	3.87	0.018	0.046	3.3 days
6	Virgo	70 Virginis	72	5	G5V	5200	0.95 / 1.9	b	6.6	0.4	0.43	116.6 days
7	Cetus	HD 19994	73	5.07	F8V	6160	1.35 / ?	b	2	0.2	1.3	454 days
8	Ursa Major	47 Ursae Majoris	43	5.1	G0V	5600	1.03 / 1	b	2.41	0.096	2.1	1095 days
								c	0.76	0.1	3.73	2594 days

	Constell-ation	Host Star	Distance from Earth (light-years)	Appar-ent Mag.	Star data / Spec Type	Star Surface Temp (K) est.	Solar Masses / Solar Radii	Planets	Planet Mass (Jupiter=1)	Eccent ricity	Avg Dist from Star (AU)	Orbital Period
9	Corona Borealis	rho Coronae Borealis	55	5.4	G2V	5700	1 / ?	b	1.1	0.028	0.23	39.65 dys
10	Pegasus	51 Pegasi	48	5.5	G2.5V	5770	1.05 / 1.4	b	0.47	0	0.05	4.23 dys
11	Ursa Major	HD 89744	130	5.7	F7V	6166	1.4 / ?	b	7.2	0.7	0.88	256 dys
12	Cygnus	Gliese 777A	51.8	5.71				b	1.15			
13	Orion	HD 38529	138	5.94	G4	5800	1.39 ?	b	0.77	0.312	0.12	14.3 dys
								c	11.3	0.34	3.51	2189 dys
14	Cancer	55 Cancri	44	5.95	G8V	5570	1.03 / ?	b	0.84	0.03	0.115	14.65 dys
								c	0.21	0.34	0.24	44.26 dys
								d	4	0.16	5.9	2785 dys

References:
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